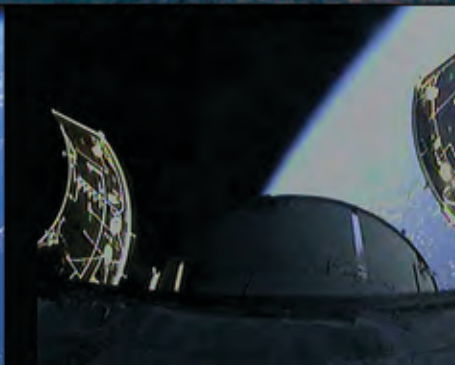




# Exploration Flight Test-1

EXPLORATION SYSTEMS DEVELOPMENT  
Combined Monthly Highlights, December, 2014

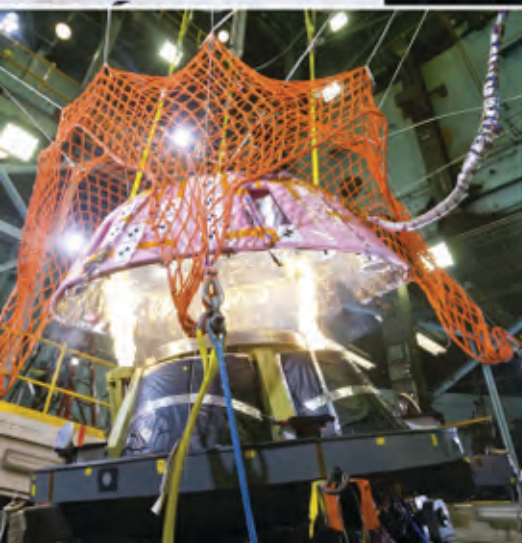




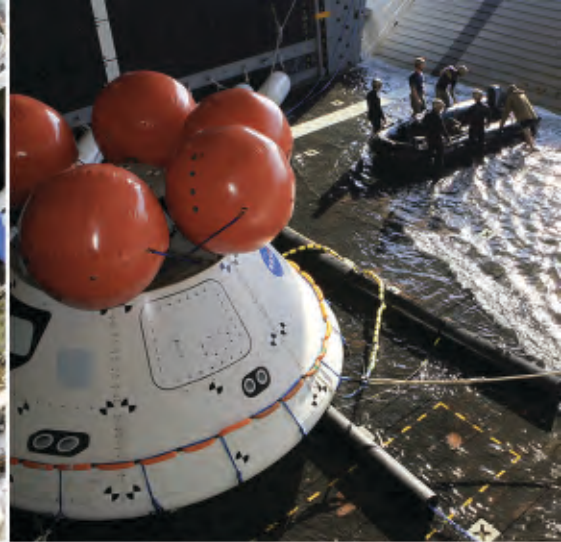


A YEAR OF PROGRESS

2014







A YEAR OF PROGRESS

2014







Dear ESD Team,

By all measures, 2014 was a hugely successful year! The progress Orion, SLS and GSDO Programs have made is remarkable and has captured the attention of the entire nation and the world. Every month in 2014 shows significant accomplishments from each program. All one has to do is look back through the monthly highlights reports to see how far and quickly we've come.

We can point to big moments like SLS passing KDP-C, Ground Systems beginning modifications on the VAB and Firing Room 4, and of course, Orion's Exploration Flight Test -1. EFT-1 was a successful flight not only in the data obtained, but in demonstrating our ability to cost effectively tailor risk relative to objectives as part of a new way of doing business. We will continue to make decisions based on the understanding of the known risks and an assessment of potential unknown risks relative to objectives.

The momentum we gained last year has propelled us into 2015. This is a good thing because we need to keep up the pace. While some may say that 2018 is a long way off, we know how quickly EM-1 will be upon us. This first test flight of the integrated exploration system will be historic; a connection among those of us wearing a badge today and future generations of space pioneers.

We have so much to look forward to in the coming months. GSDO will complete structural modifications to the Mobile Launcher, SLS will test fire it's booster and complete Critical Design Review, Orion will take what they have learned from EFT-1 and build an even more robust crew capsule for the future.

There will be plenty of exciting, big moments. There will also be our fair share of challenges. What makes the big moments possible are all of the smaller moments; your day-in and day-out dedication, attention to detail, problem solving and teamwork is what brings us to this point of achievement. It is going to take the whole team and lots of "smaller moments" to get this right. At the top of all of our minds must be integration. We must think in those terms and communicate freely to that end. We must remember that as we are a team of teams, so we are building a system of systems.

I want to thank each one of you for doing your part in this endeavor. I hope you are as excited as I am to watch our designs turn into hardware, and our hardware turn into an integrated stack rolling out to Pad 39-B.

Happy New Year,

Bill Hill



National Aeronautics and  
Space Administration



# ORION

DECEMBER 2014

**THERE'S  
YOUR NEW  
SPACECRAFT,  
AMERICA!**





**NASA marked a major milestone on its journey to Mars as the Orion spacecraft completed its first voyage to space during Exploration Flight Test-1, traveling farther than any spacecraft designed for astronauts has been in more than 40 years.**

Orion blazed into the morning sky at 7:05 a.m. EST on Dec. 5, lifting off from Space Launch Complex 37 at Cape Canaveral Air Force Station in Florida on a United Launch Alliance Delta IV Heavy rocket.



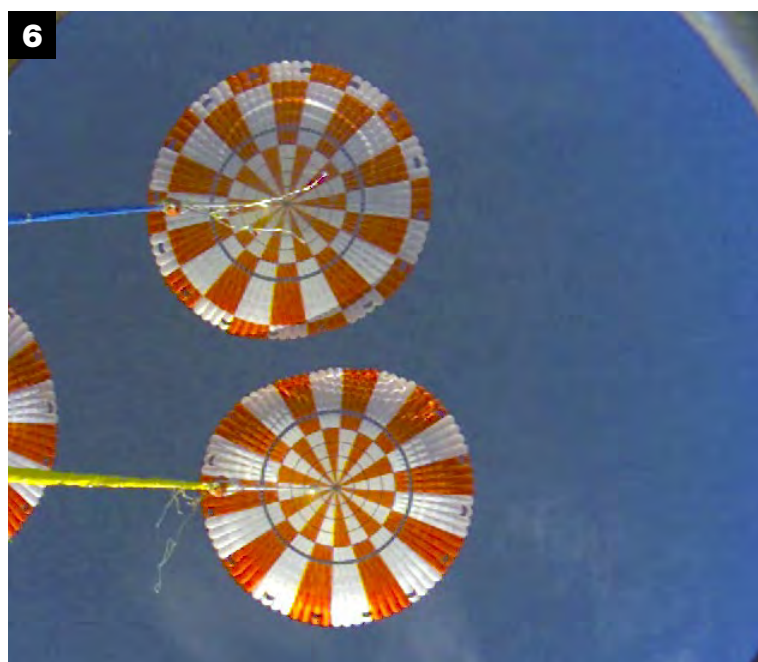
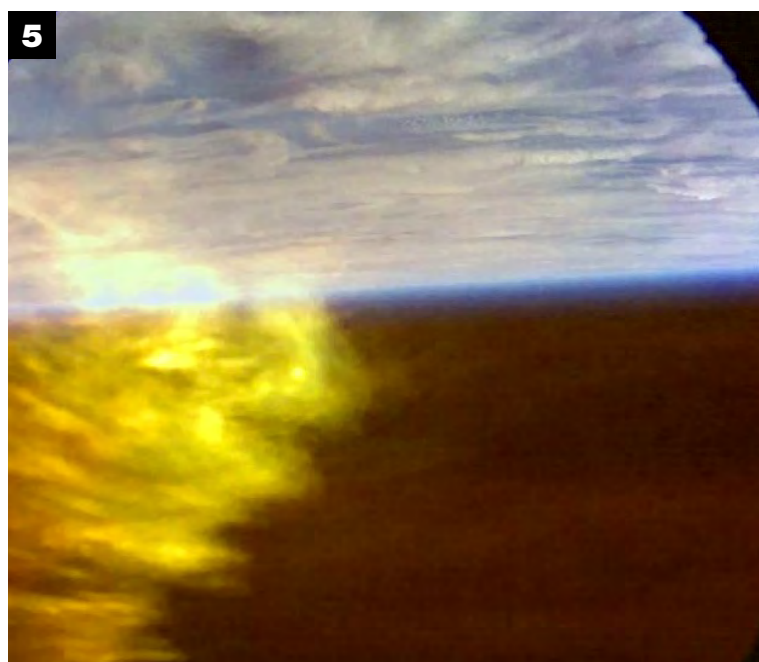
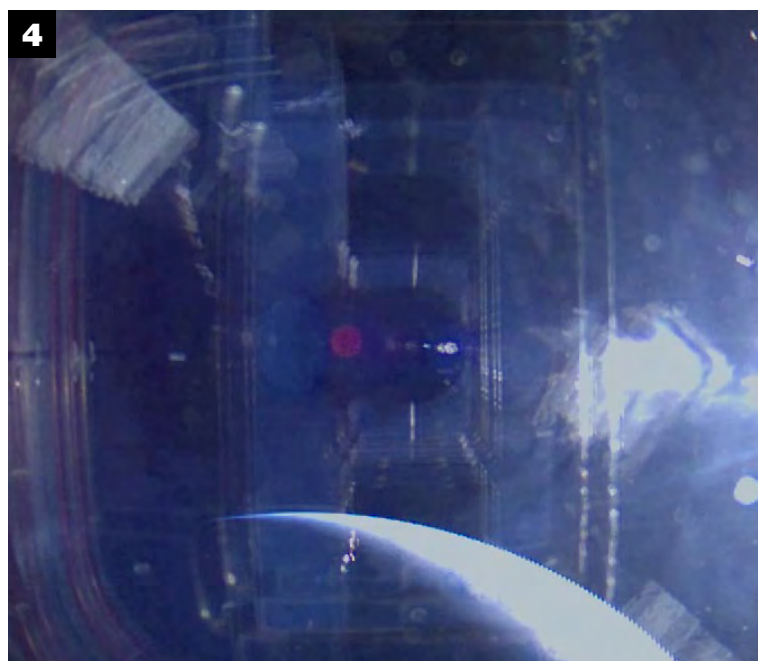
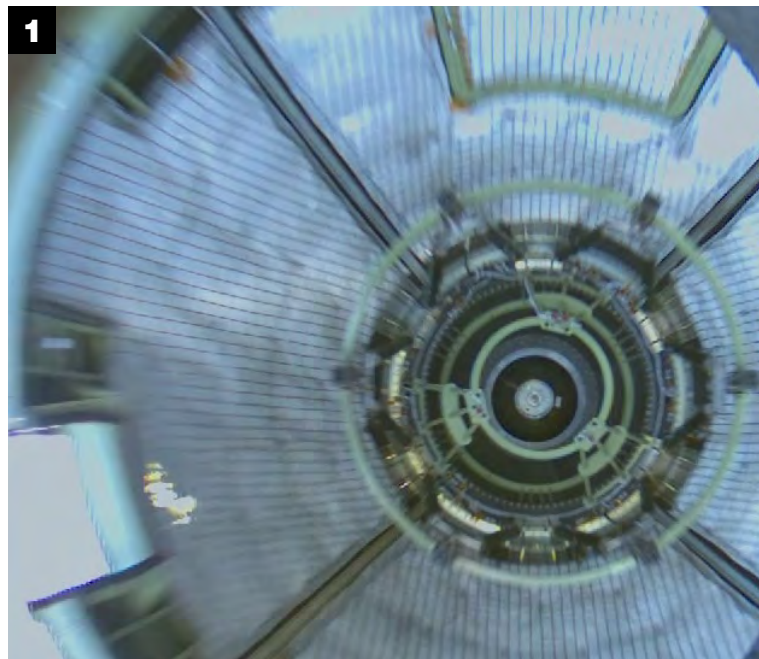




NASA and Lockheed Martin senior management were on hand to witness the picture perfect launch, as were Orion family and friends who gathered along the NASA causeway.









During the uncrewed test, Orion traveled twice through the Van Allen belt where it experienced high periods of radiation, and reached an altitude of 3,600 miles above Earth. Orion also hit speeds of 20,000 mph and weathered temperatures approaching 4,000 degrees Fahrenheit as it entered Earth's atmosphere.



**Previous page:**

1. Launch abort system separates
2. Service module fairing panels separate
3. Crew module separates from service module
4. Earth seen through window from 3600 miles away
5. Plasma envelops crew module during reentry
6. Parachutes open as Orion returns to earth





Throughout the flight test, NASA and Lockheed Martin Orion management kept a watchful eye on the status of the vehicle. The flight tested many of the systems critical to crew safety, including key separation events, parachutes and the heat shield.

**Top-left:** Mike Hawes, Lockheed Martin vice president and Orion program manager; Mark Geyer, NASA Orion program manager; and Mark Kirsich, NASA Orion deputy program manager.

**Top-right:** Mike Sarafin, Exploration Flight Test-1 flight director.

**Left:** Charles Bolden, NASA administrator, and William Gerstenmaier, associate administrator for Human Exploration and Operations for NASA.

**Bottom-left:** John Casper, astronaut and special assistant for Orion program integration, and Carol Webber, Lockheed Martin director, Exploration Mission 1.

**Bottom-right:** William Gerstenmaier, Mark Geyer, and Ellen Ochoa, director of NASA's Johnson Space Center.





After a 4.5-hour flight, the Orion crew module splashed in the Pacific Ocean, 600 miles southwest of San Diego. A team of NASA and U.S. Navy personnel aboard the USS Anchorage recovered the spacecraft and returned it to the U.S. Naval Base in San Diego.





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DECEMBER 2014

5...4...3...2...1...

# SPACE LAUNCH SYSTEM HIGHLIGHTS

## NASA's New Orion Spacecraft Completes First Spaceflight Test

NASA marked a major milestone Dec. 5 on its journey to Mars as the Orion spacecraft completed its first voyage to space, traveling farther than any spacecraft designed for astronauts has been in more than 40 years. (Photo essay continued on Page 2)



The United Launch Alliance Delta IV Heavy rocket with NASA's Orion spacecraft mounted atop, lifts off Dec. 5 from Cape Canaveral Air Force Station's Space Launch Complex 37. (NASA)



## ...Orion Spacecraft Completes First Spaceflight Test



NASA Administrator Charles Bolden, left, NASA Associate Administrator for the Human Exploration and Operations Directorate William Gerstenmaier, and others in Hangar AE at Cape Canaveral Air Force Station in Florida react as they watch the Orion spacecraft splash down in the Pacific Ocean more than four hours after launch. (NASA)



A video camera onboard NASA's Orion spacecraft captured views out the window during the heat of re-entry as the capsule plummeted back toward Earth. (NASA)



Recovery team members in a Zodiac boat help guide NASA's Orion spacecraft into the well deck of the USS Anchorage following its splashdown in the Pacific Ocean. (U.S. Navy)



The Orion crew module is moved by crane Dec. 13 from its crew module recovery cradle and placed in the crew module transportation fixture at the Mole Pier at Naval Base San Diego in California. (NASA)



Welcome home! On Dec. 18, Orion arrives at Kennedy Space Center in Florida. (NASA/KSC)



# Spaceflight Partners: Scot Forge

*EDITOR'S NOTE: Every month, SLS Highlights turns the spotlight on one of the many industry partners helping to create the largest rocket ever built for human space exploration. In this issue, we profile Scot Forge of Spring Grove, Illinois.*



*Scot Forge headquarters in Spring Grove, Illinois. (Scot Forge)*

Scot Forge is a 100-percent employee-owned manufacturer of custom open die forgings and seamless rolled rings. The company's roots date back to 1893 when their doors opened as a small hammer shop in Cicero, Illinois. Over the past century, the company has grown to become one of the largest forge shops in the country. As an industry partner to organizations such as ATK and NASA, supporting the Space Launch System is an effort made possible on many fronts.

Scot Forge produces a wide variety of critical components that contribute to NASA's Exploration Systems Development programs. Forged parts made by Scot Forge have been installed into the Mobile Service Tower and Crawler Transporter at NASA's Kennedy Space Center in Florida, and test stands at ATK in Promontory, Utah, and the agency's Marshall Space Flight Center. Flight hardware in nonferrous alloys has been adopted for use on the Launch Abort System for Orion, the Orion spacecraft itself and the SLS core stage. This holistic involvement is a cornerstone of the company's approach for serving

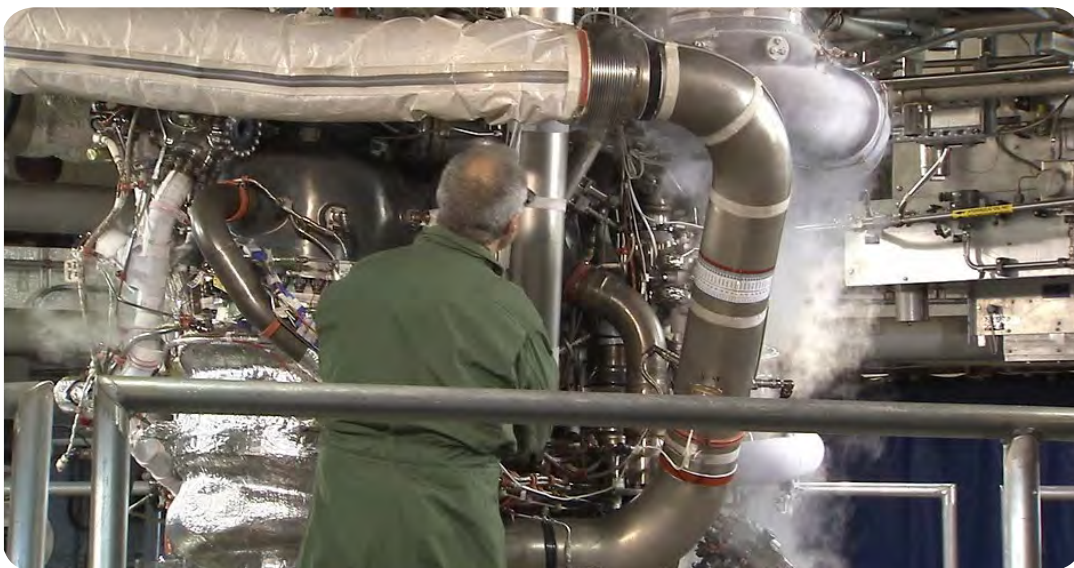
the space industry, whether it's ground support equipment or extraterrestrial rovers.

Recently, ATK and Scot Forge partnered in the development of the robust Main Pivot Flexure for ATK's T-97 Test Stand. The challenge was to jointly develop a component that could withstand the incredible forces being exerted by the five segment SLS solid rocket booster. The thrust loads are transferred through the main pivot flexure into the forward test stand and the load cells resulting in motor thrust readings.

Ultimately, it was agreed to pursue a monolithic forging design that would be made from a high-strength stainless steel. Scot Forge technicians were challenged to meet critical strength and toughness requirements. Advanced forging practices, heat treat modeling and tight process control all helped to optimize the manufacturing parameters. The result of this effort yielded a product that exceeded even the highest expectations. The test firing on the T-97 Test Stand is scheduled for March 11.



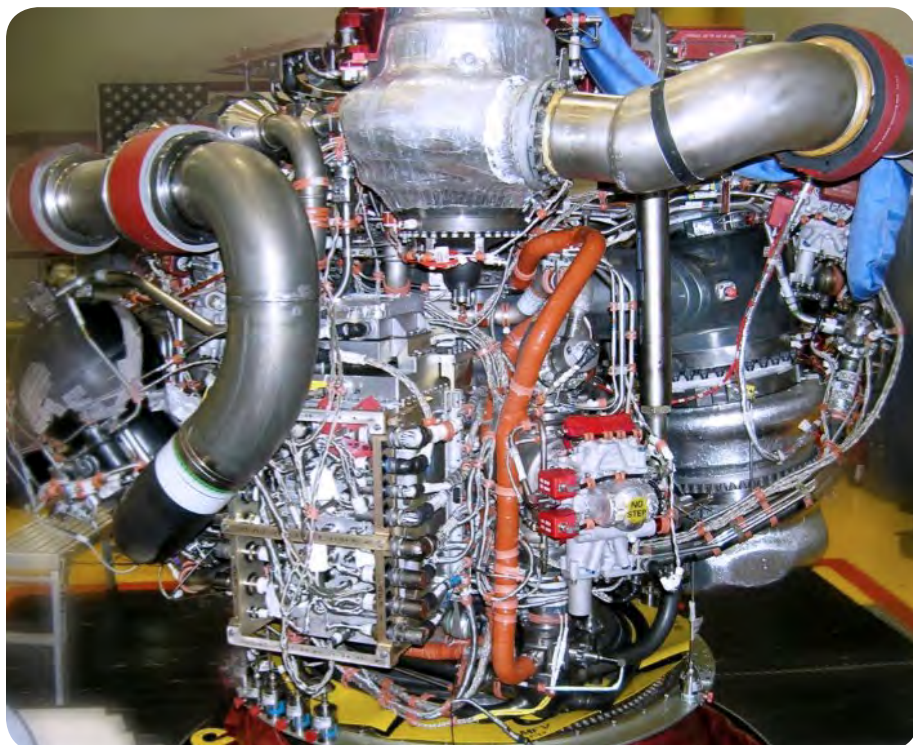
## Chill Test, Warm Success



NASA engineers at Stennis Space Center near Bay St. Louis, Mississippi, took a major step Dec. 11 towards hotfire testing of RS-25 rocket engines that will help power the SLS on missions to deep space destinations. A-1 Test Stand operators at Stennis completed a chill test of developmental engine No. 0525, clearing the way for hotfire testing to begin in 2015. A chill test is a full dress rehearsal for hotfire testing. More information can be found [here](#). (NASA/Stennis)

## New “Brain” for RS-25 Engine is No Technological Flashback to the ‘80s

Take a look at your current devices. Can you imagine swapping that smartphone for a gigantic cellphone from the 1980s? Surfing the Internet with dial-up speed? Working out to your favorite music with a cassette player? Today’s technology is better, faster and more innovative. People have to keep up with the rapidly changing times, and so does the “brain” for the RS-25 rocket engine. For the full story click [here](#). (NASA)





## Pegasus Barge Continues Modifications for SLS



Work continues on NASA's Pegasus barge, which is undergoing refurbishments at Conrad Shipyard LLC in Morgan City, Louisiana. Conrad crews recently built and replaced the vessel's 115-foot center section with a new, 165-foot center section. The team also is finishing the final welds, surface preparation and painting for the barge. The modifications increased the total length of the barge from 260 feet to 310 feet—a little more than the length of a football field. The barge modification work, acceptance testing and delivery are scheduled for completion in March 2015. Pegasus will carry the core stage of SLS. (NASA)

## It's Beginning to Look a Lot Like a Test Stand for SLS

Progress continues! Some 156 truckloads of concrete were successfully poured Dec. 13 for a new, 215-foot test stand at NASA's Marshall Space Flight Center in Huntsville, Alabama. Test Stand 4693 will be used for structural loads testing on the liquid hydrogen tank for the core stage of SLS. The 4693 structure—being built on the foundation of the stand where the Saturn V F-1 engine was tested—will have a twin-tower configuration and be made with more than 2,500 tons of steel when completed in 2015. After the concrete cures, crews will begin preparing for the next concrete pour on the stand, including setting inner anchor rods and reinforcing steel. (NASA/MSFC)





# SLS On the Road...

SLS had a great time supporting Orion's first flight test!



(Media Fusion)



(NASA/MSFC)



(NASA/JSC)

Follow SLS on:

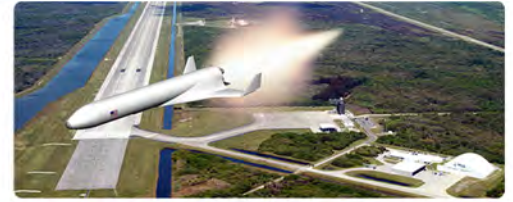


(Media Fusion)

## SLS on Deck:

- SLS antieyseyer testing complete
- First RS-25 engine test
- Modifications continue on Pegasus barge





At NASA's Kennedy Space Center in Florida, the Ground Systems Development and Operations (GSDO) Program Office is leading the center's transformation from a historically government-only launch complex to a spaceport bustling with activity involving government and commercial vehicles alike. GSDO is tasked with developing and using the complex equipment required to safely handle a variety of rockets and spacecraft during assembly, transport and launch. For more information about GSDO accomplishments happening around the center, visit <http://go.nasa.gov/groundsystems>.

## Orion Completes Flight Test to Earth Orbit and Return

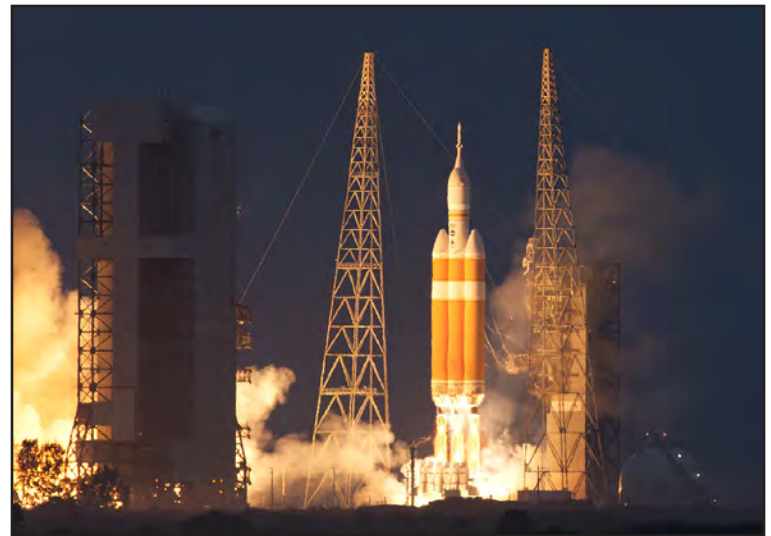
A spacecraft built for humans left the domain of low-Earth orbit Dec. 5 for the first time in 42 years when NASA's first Orion soared 3,604 miles above Earth and returned safely hours later, having accomplished a flawless flight test as part of NASA's journey to Mars.

"We as a species are meant to press humanity further into the solar system and this is a first step," said Bill Gerstenmaier, NASA's associate administrator for the Human Exploration and Operations Directorate. "What a tremendous team effort."

It was just the kind of mission NASA hoped for, all the while knowing that the first mission by any spacecraft often turns up significant glitches. That was not the case this time though. The cone-shaped Orion held up to all the pressures of launch and ascent into orbit, then made two passes through the high radiation of the Van Allen belts before facing the searing plunge into Earth's atmosphere and splashing down under three billowing parachutes.

Watching the spacecraft descend through the sky over the Pacific Ocean in real time via an unmanned aircraft system dispatched from NASA's Armstrong Flight Research Center in California, Orion managers and NASA's senior leadership seemed to hold their breath until the first drogue parachutes deployed from the nose of Orion. Gasps turned quickly to applause and hugs moments later when the huge main parachutes opened to slow the capsule to a gentle 20 mph splashdown 270 miles west of Baja California.

Orion touched down about a mile away from the land-



A Delta IV Heavy rocket lifted off from Space Launch Complex 37 at Cape Canaveral Air Force Station on Dec. 5 carrying NASA's Orion spacecraft on an unpiloted flight test to Earth orbit. Liftoff was at 7:05 EST. Photo credit: NASA/George Roberts

ing spot controllers predicted before launch, achieving a statistical bulls-eye splashdown for something returning to Earth from 3,600 miles away.

Engineers will evaluate all the data recorded on the ground and on the spacecraft's onboard systems including readings from 1,200 sensors placed throughout the crew module to find out more details about all the elements of the spacecraft and the details of their performance.

To read the complete story, visit <http://go.nasa.gov/1BDD4Lj>.



# NASA, U.S. Navy Recover Orion after Splashdown in Pacific Ocean

Ships were deployed, helicopters circled above, weather balloons were launched, and U.S. Navy divers embarked in several small boats, about 600 miles southwest off the coast of San Diego, all to aid in recovery of NASA's Orion spacecraft Dec. 5. The planning, rehearsals and hard work paid off for the Orion Recovery Team, led by the Ground Systems Development and Operations Program at NASA's Kennedy Space Center in Florida.

"The recovery of Orion was flawless," said Jeremy Graeber, NASA recovery director. "We wanted to be patient, take our time. We didn't rush."

Earlier in the week, NASA, the U.S. Navy and Lockheed Martin personnel left Naval Base San Diego aboard the USS Anchorage, an amphibious ship, and the USNS Salvor, a safeguard class salvage ship, to make preparations and rehearse the

**To ORION RECOVERY, Page 3**



*The Orion crew module was recovered Dec. 5 after splashdown in the Pacific Ocean about 600 miles off the coast of San Diego, California. NASA, the U.S. Navy and Lockheed Martin coordinated efforts to recover Orion and secure the spacecraft inside the well deck of the USS Anchorage. Photo credit: Courtesy of U.S. Navy*



*U.S. Navy divers in Zodiac boats prepare to recover the Orion spacecraft and tow it in to the well deck of the USS Anchorage on Dec. 5. Photo credit: Courtesy of U.S. Navy*



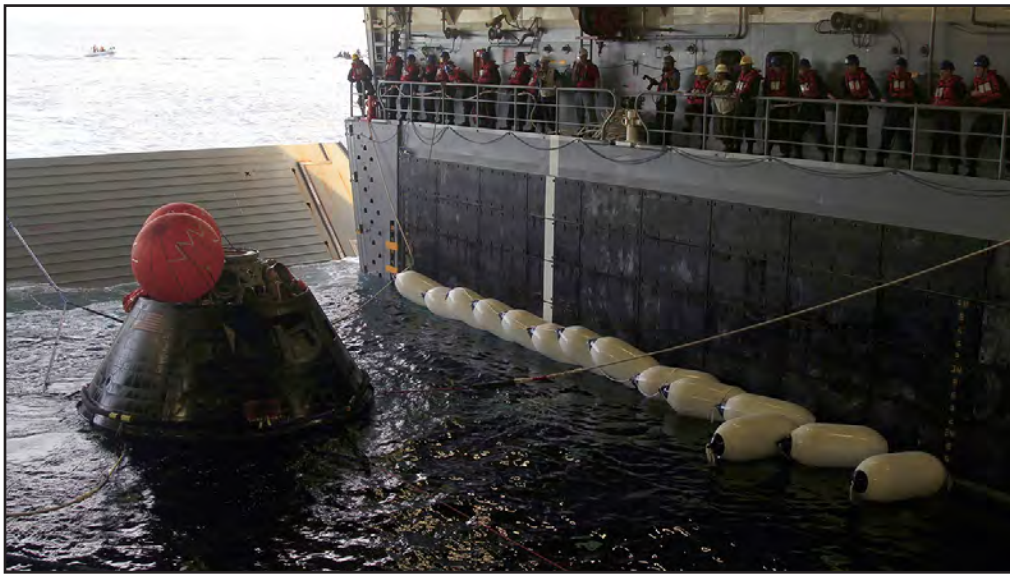
*NASA's Orion spacecraft floats in the Pacific Ocean after splashdown Dec. 5 from its first flight test in Earth orbit. An H60-S Seahawk helicopter hovers above to communicate the spacecraft's location back to the USS Anchorage. Photo credit: Courtesy of U.S. Navy*

## A Note from the Director

December 5, 2014 was a great day for NASA! The launch was beautiful. The Orion spacecraft performed superbly, and the GSDO team completed a successful recovery of the crew module into the well-deck of the USS Anchorage. It takes a cross-center, cross-program team to make it all happen, and I couldn't be prouder of our team and our role in the accomplishment. This is our program and this is a huge step forward on our mission to send human beings to Mars.







NASA's Orion spacecraft is secured with tether lines inside the flooded well deck of the USS Anchorage on Dec. 5 in the Pacific Ocean. Photo credit: NASA/Cory Huston



The USNS Salvor is nearby as the Orion spacecraft is being towed by a winch line into the well deck of the USS Anchorage on Dec. 5. Photo credit: NASA/Cory Huston



The Orion spacecraft is viewed by members of the media Dec. 19 at the Launch Abort System Facility at Kennedy Space Center. Orion made the 2,700 mile road trip from Naval Base San Diego in California back to Kennedy. Photo credit: NASA/Dimitri Gerondidakis



capture and recovery of the Orion crew module and main parachutes.

One hour after splashdown, the flight control team that saw Orion through its flight handed control of the vehicle off to the recovery team. Orion was powered down, put in a safe mode, and the recovery process began. U.S. Navy divers in several rigid hull and Zodiac boats proceeded to Orion.

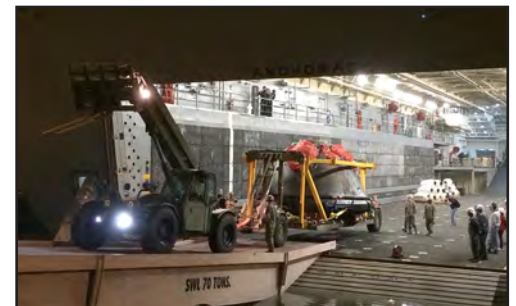
Divers took underwater photos of Orion's heat shield. Then, they attached a collar and winch line to the spacecraft. A series of tending lines also were attached to help safely tow Orion into the flooded well deck of the USS Anchorage and position it over rubber "speed bumps."

Two of the three main parachutes were recovered and lifted onto the USS Anchorage.

As the ships headed back to land, the USS Anchorage's well deck was flooded again so Orion could be secured on its crew module recovery cradle, built by Orion prime contractor Lockheed Martin.

The ships returned to Naval Base San Diego on Monday, Dec. 8, and Orion and the ground support equipment were offloaded. The recovery team prepared Orion for transportation over land by truck back to Kennedy Space Center in Florida.

To read the complete story, visit <http://go.nasa.gov/13rVMXn>.



NASA's Orion spacecraft is offloaded from the well deck of the USS Anchorage at Naval Base San Diego in California on Dec. 8. Orion has been secured in its crew module recovery cradle and will be prepared for return to Kennedy Space Center in Florida. Photo credit: NASA/Amber Philman